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nut, yet all are found living with us, as well as largely represented in our Dakota fossils. Europe has no Catalpa, but we have the fossil Protophyllum, which appears to be nearly the same.

It is also a fact of much interest to note that the proportion of apetalous and polypetalous plants, of imperfect and perfect flowers, in Prof. Lesquereux's list, is very nearly the same in the Dakota group as in our living flora.

According to our present geological knowledge, the American lower cretaceous contains the first and oldest Dicotyledons. Future discoveries may give us a still further antiquity to our forests. But as the early Cretaceous flora has been known for many years, and carefully studied without finding anything of the same type in any of the older formations, it is very probable that we must date the origin of the Dicotyledonous plants with the dawn of the Cretaceous age.

At the close of the Dakota epoch we know that a long period elapsed, extending to the close of the Cretaceous, during which all portions of the United States from the Atlantic to the Pacific, excepting a few islands, and probably the southern part of British America, was under the ocean. It was the reign of the large fishes, saurians, etc., found fossilized in Western Kansas, Nebraska and Wyoming. During this time the forests became locally extinct. But their representatives are found in the northern regions in the Upper Cretaceous, over extensive areas, that betoken a continent, or at least continental islands. The leaves and other remains of the forests occur in Alaska, near Mackenzie river, North Somerset and Greenland; and undoubtedly at intermediate points.

These facts, and the strong resemblance between the floras of the Dakota period and those of Alaska, Mackenzie and Greenland, together with their common alliance to our living forests, justify us in concluding that the vegetation of our lowest Cretaceous slowly migrated; and, the climate in the northern regions then being like that of Virginia and the Carolinas at the present day, it overspread a large extent of the northern regions, far within the Arctic Circle. When in the Tertiary times, the sunken continent arose again, the flora, returned to its former home. As the Rocky mountains arose in the Eocene it came back by the way of that backbone of the continent, and thence spread over the whole of the temperate zone of North America. Those with a preference for mild winters inclined to the western slopes, and others took their way toward the East, as Prof. Gray has narrated. Many small shrubs, protected by the large trees, went and came with them.

When we consider the long periods covered by the Cretaceous and Tertiary ages, the rate of migration may have been exceedingly slow. If we allow a century for a life generation of each forest, the seed of the trees need not have been carried more than a single mile in a single generation. Thus slow but sure is the plan of nature's operations.

INTERNAL HEAT OF THE EARTH.

By Prof. B. F. Mudge.

We frequently notice, in newspapers and popular treatises on geology, the theory stated, in the most deliberate manner, as if it were accepted by all scientific men, that heat rapidly and regularly increases from the surface to the center of the earth. They tell us that at the depth of twenty or thirty miles, and from thence to the center, the whole mass of the globe is in a fluid, molten state, having an intensity of heat which even the imagination of the chemist can hardly comprehend. This theory is based on the hypothesis that, starting from the surface, there is a constant and uniform increase of heat, at the rate of one degree F. for every forty-five feet in depth. This would give a temperature of 212°, or that of boiling water, at little more than a mile. As iron melts at 3,000°, that temperature would be reached at twenty-five miles. At a depth of about fifty miles a heat would be found, sufficient to melt the most infusible rocks. Most of our strata, like limestone, would yield at a less heat. At the center of the earth, by the popular ratio, it would be 600,000°, or eighty-five times greater than that required to melt any combination of natural elements (except platinum) found in the earth's crust. Some observations make an increase of heat equal to one degree for every thirty-two feet. This would place the molten ocean nearer the surface of the earth, the crust thinner, and the heat at the center more intense.

This theory was advanced by some of the early writers, on a limited array of facts, and a narrow comprehension of nature's laws. We know of no geologist of high standing at the present day who sustains this theory.

The first and great objection to this hypothesis lies in its opposition to well-known chemical laws. Every chemist who fuses metals in the laboratory, and every furnace-man in our iron, zinc or copper foundries, knows that when he has raised his crucible, or furnace, to the melting point of any metal, he can by adding fuel raise the molten material to far higher degrees of heat, but if he throws in pieces of the unmelted metal the temperature will not rise beyond the melting point, till the last ounce has become liquid. Thus, lead will melt at 625°, but after melting, its temperature can be raised hundreds of degrees till it boils, or even becomes vapor. But if when the lead has just reached the melting point, bars of lead, or even shot, are added to the liquid surface of the furnace, the temperature will be constant at 625°. This rule applies to all known substances. It is often seen in the familiar example of water. So long as a fragment of ice remains in our kettles, no fire will raise the temperature of that fluid above 32°. Apply this simple chemical test, and it at once settles this question, that the interior of the earth, if liquid, can not be above the melting point (7,000°) of the most refractory portions of the earth's crust. If the heat of the interior exceeded that point, this thin crust, whether of twenty-five or one hundred miles, would be immediately melted into the common mass, and we should not be here today to discuss its plausibility.

Still, it remains to consider how far we have any data to fix the rate of increase of heat, and at what depth the crust of the earth may be in a melted state. Let us look at the facts on which the theory of a regular and uniform increase of heat downward, is based.

Prof. Wm. B. Rogers, on examination of the coal mines of Eastern Virginia, computed the increase at one degree for every sixty feet. In the United Copper Mines of Cornwall, 1,201 feet deep, the increase is about half as much, or thirty-one feet to a degree of heat. At the coal mine at Ravin, France, 597 feet deep, the increase is one degree for every fifty-five feet. At another coal mine in the same country, at Castellan, 630 feet deep, one degree to forty-one feet. At another at Littry, 325 feet in depth, one degree for thirty-six feet. At a coal mine at Wigan, Lancashire, England, 750 feet deep, one degree for each forty-eight feet, but far from a uniform rate of increase at various depths. At the coal mine near Sunderland, England, 1,584 feet deep (going 1,500 feet deper than the sea level), the increase is one degree in sixty feet. At the Dolcoath mine, Cornwall, 1,381 feet deep, one degree for every fifty-four feet. But the mine at Bechertgluck, Saxony, calls for particular attention. The whole depth is 1,246 feet. For the first 236 feet from the surface the increase of heat is at the rate of one degree for every 175 feet. For the next 316 feet, one degree for each sixty-four feet. For the next forty feet, about one-third of a degree. Then for 289 feet, one degree for each sixty-seven feet, and for the remaining 366 feet, one degree for sixty-five feet. Thus we have five different rates of increase in one mine, the extremes being one degree for 175 feet, and sixty-four feet, or a variance of 275 per cent. This shows that in this mine—a very deep one—there is no systematic rule for the increase of heat with the depth. It will be noticed, also, that the extremes of variation are included in a depth of 552 feet. As this is a variation caused by local influences, may not the heat in other mines be also owing, in a greater or less degree, to local causes? The lead and silver mine of Kurpinz, in the same country, shows a similar example of variation. The mine is 1,063 feet deep. For the first 413 feet the increase is one degree for each thirty-one feet. For the next 273 feet it is at the rate of one degree for each forty-three feet; and from thence to the bottom of the mine, 377 feet, at the rate of one degree for fifty feet. Here is a variance of sixty-one per cent. An increasing ratio, but not a uniform one. In the immediate vicinity is another mine, Junghöke, where the increase is one degree to 102 feet.

Springs in mines, and more particularly artesian borings, which have been carried to great depths, have been quoted to show the same law of increase. The results of the observations are far more variable.

In a spring in the mine of Kurpinz, 634 feet deep, the increase is one degree for each nineteen feet. At Westphalia, in a well 2,200 feet deep, the increase is one degree for fifty feet. At Yakutz, Siberia, in a well 407 feet deep, Magnus found a gain of one degree for each twenty-seven feet. Other places in Siberia show that the increase varies from thirty to as low as fourteen feet to each degree.

The springs in the lead mines at Paullanen, Britany, show an increase varying from eighty-two feet to 351 feet, to one degree of heat.

At an artesian well near Berlin, 675 feet deep, there are three degrees of ratios of increase, being one degree for twenty-eight, thirty-five and thirty-six feet, respectively. In America the artesian wells are equally at variance with any settled law of increase. At New Brunswick, N. J., at a well 394 feet deep, there is an increase of a degree for every seventy-two feet. At Charleston, S. C., 910 feet in depth, a well gives one degree to each sixty-four feet. At Connelsville, Ohio, 400 feet deep, a boring gave one degree to 120 feet. Another at the same town, 819 feet deep, gave no increase. A well also, near Chicago, about 1,200 feet, showed "no appreciable increase of heat."

The Artesian well in the State House yard, at Columbus, Ohio, 2,575 feet deep, gave a degree for every seventy-one feet. At Louisville, Ky., a well 2,086 feet deep gave a degree to seventy-four feet. The well at St. Louis, Mo., the deepest in America, 3,843 feet, is the most remarkable. At 3,029 feet it showed a nearly uniform increase of fifty-seven feet to a degree, but for the remaining 814 feet it decreased two degrees, or a loss of a degree for each 407 feet.

If this rule of a regular increase of heat were a reliable one, we might expect that the waters of the ocean would show a large increase of heat as we penetrate its depths. But no such result has been discovered. On the contrary, all our deep sea soundings show a state of temperature adverse to this theory. According to nearly all the facts in our possession, instead of a theoretical rate of increase, there is a steady and somewhat uniform decrease, so that the bottoms of the great oceans are near the freezing point of fresh water. The soundings on the Telegraph Plateau, in the North Atlantic, sustain this, as the water was usually, at the bottom, below 40°. Off the coast of Norway, lat. 76° 17′, long. 13° 53′ E., the temperature at the bottom, 9,000 feet deep, was 32° and 33°, while the surface was 41°. The numerous soundings, both in the Atlantic and Indian oceans, by the Challenger, show that all the deep portions of these oceans were of a uniform cold temperature, much below that of the surface. But the rocks underlying the great oceans, twenty and thirty thousand feet, are so much nearer the hot regions of the earth, that they should, if the popular theory is true, be far above the average temperature of the surface, if not to a high, almost boiling degree.

That the interior of the earth has a higher temperature than the surface appears to be certain, but that a moderately high percentage of it is in a molten state is not sustained by science. The examples we have given, and many more of a similar character might be added, show that there is no regular rule which will give us even an approximate knowledge of the heat of the center of our globe.

Some very valuable scientific investigations were made many years ago, by Prof. Hopkins, of London, in relation to this question. His conclusion was, that the crust of the earth was not less than eight hundred miles in thickness, and that the fluid portions of the interior, were little, if any, above the melting point of refractory rocks.

Sir Charles Lyell, in Principles of Geology, says of the theory of the intense increase of heat toward the interior of the earth, "It seems wholly inconsistent with the laws which regulate the circulation of heat through fluid bodies." The fluid portions under volcanos must, therefore, be regarded as exceptional and local.

Prof. J Le Conte, in his recent work, says we must base our geology on substantially a solid globe. Prof. J. D. Dana, in his last edition of the Elements of Geology, makes about the same conclusion.

KANSAS MOUNDS.

By F. G. Adams, Topeka.

The first recorded mention of ancient mounds in Kansas, was made of mounds near Fort Leavenworth, by Rev. Isaac McCoy, in his account of the survey made by him, of the boundary lines of the Delaware Indian reservation in 1830. This Mr. McCoy was one of the first to bring forward the project of transferring to Kansas, from the East, the Indians of the various emigrant tribes which the settlers of Kansas found here twenty-three years ago, occupying large portions of what is now the most populous part of this State, but who have since that time nearly all been removed to the present